The Language of Architectural Diagrams

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Abstract

Complex buildings frequently present a challenge to users' understanding, which may affect wayfinding as well as appreciation of the building's structure. In this paper we focus on the building's *diagram*, a representation by the building's architect that captures its main 'idea'. Motivated by the intuition that a building may be easier to understand if its conceptual diagram can be clearly and easily described, we explored perceivers' descriptions of such diagrams' features. We asked students of Language and students of Architecture to write about the buildings represented in a variety of diagrams, and then repeated the task for photographs of the actual buildings. Using Cognitive Discourse Analysis, we aimed to create a first qualitative exploration of the linguistic and conceptual patterns that are associated with the perception of diagrams and images of complex buildings. Among other factors, results show how perception of the diagram's meaning is fundamentally affected by subject expertise. Linguistic patterns demonstrate the ways in which written descriptions reflect observers' understanding and concepts of building representations, providing a starting point for future studies which may address the possible relationship between the *verbalisability* of a diagram and the *legibility* of a building.

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1 Introduction

Have you ever stood in front of a complex public building, marvelled at its strange and fascinating forms – and wondered how to make sense of it, locate the entrance or how to find your way around inside? The building shown in Figure 1, Museu Paula Rego in Cascais, might trigger such thoughts – impressive and perhaps a bit intimidating. How easy is it to understand such buildings?

To represent our understanding of a complex building, how would we describe it in language? Words are, after all, our most commonly used tool to represent the world and our understanding of it. We use language to communicate our thoughts to others, and to express and develop our thought processes [5]. To some extent, people's concepts of a building can therefore be accessed by a close look at how they talk (or write) about them,

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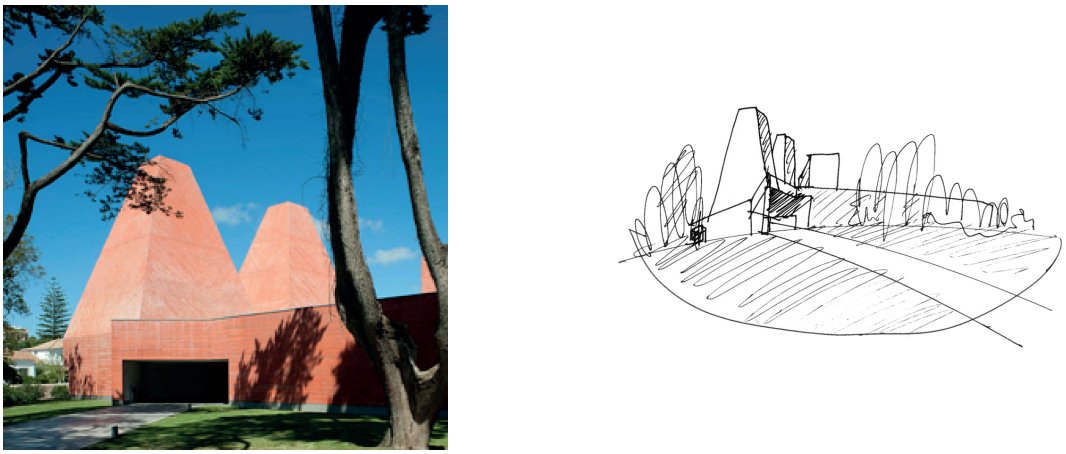

Figure 1 Museu Paula Rego, Cascais: Photograph and architectural diagram. Photograph, left, is copyright Chia Hsien Liao ('LeonL') and made available under a Creative Commons Attribution 2.0 Generic license. Diagram, right, copyright Eduardo Souto Moura and used with permission.

i.e. by analysing verbal descriptions. In the context of architectural concepts, we might expect that the complexity of buildings and the concomitant understanding of them should be represented in linguistic description. Ultimately, we would also expect that a building that can be clearly understood (and hence clearly verbalised) should also be easy to use, or *usable* – applying a previous definition by Krukar et al. in which they suggest that "A building is usable when it allows the user to execute his/ her tasks effectively, efficiently and with satisfaction in the specified context of use." [14]. To a high extent, this will in practice depend on *navigability*, i.e. the ability to navigate to a destination within the building. This presupposes a degree of understanding of the building's structure, and thus relates to Lynch's idea of *legibility*: namely, "the ease with which its parts can be recognized and organized into a coherent pattern" [15].

Unique buildings such as the one shown in Figure 1 are designed by architects on the basis of an initial idea or concept, frequently represented in an architectural diagram (a notion we'll examine in some depth in Section 2), such as the one shown on the right. A diagram represents the architects', not the users', conceptualization – and it does so in visual form, not in language. Intuitively, there should be a connection: If a diagram and its associated building are easy to understand, they should also be relatively easy to put into words. However, the literature so far offers few insights as to how buildings, or their diagrams, are described intuitively by speakers with different degrees of architectural expertise. In this paper, we therefore start by exploring the ways in which various types of diagrams are verbalised by students of architecture and (for comparison) of language-related subject areas.

2 Architectural diagrams

A diagram can be thought of as a particularly specialist sub-class or type of drawing, in which a number of simplified or often symbolic depictions of real world objects are used to represent complex relations between those objects. The use of diagrams, who produces them, for what reasons, the features that they contain, and how they are used to communicate ideas have been the focus of study in various ways: for example the classic studies on the nature

Table 1 Characteristics of architectural diagrams and their production ("diagramming").

Who?	Primarily architects–sometimes working alone, sometimes working in a team. Less used by non-architect members of the team although they may still be active participants in the process
What?	Feature set consisting of (from Do, 2001): 1. configurations 2. connections 3. shapes 4. orientations 5. physical form/s
Where?	Typically, but not exclusively, produced in the architecture studio, office or atelier (yet includes the 'back of napkin' sketch)
When?	During the design process, particularly at an early, more explorative stage
Why?	To explore and resolve ideas as well as to produce insights and inferences (Do, 2001). To negotiate between 'determinacy and indeterminacy' (Buchanan, 1992)
How?	Typically a freehand sketch on paper (or paper equivalent) using pen/pencil/charcoal etc.

of representation by Peirce [17] and later Goodman [7] or on the use of diagrams in specific contexts such as in scientific texts [8]. In this paper we focus on the very particular type of diagrams, as used by architects. Architectural diagrams are typically produced during the design process [16]; they may be the "key form of visual thinking within architecture" [2].

In Table 1 we outline a range of characteristics of architectural diagrams and their production, which set them apart from the diagrams produced by other disciplines. Do [4] argued that the main distinctive feature of architectural design diagrams, as compared to diagrams in other domains, is "that the elements and spatial relations correspond to physical elements and spatial relations in the architectural problem". While diagrams often depict real world objects, it is only in architectural diagrams that the spatial relationships between those real world objects are elevated to a level that gives them equal to, if not greater importance than, the real world objects being depicted. This is because architecture is essentially a spatial (and specifically a spatial configurational) art: as Hillier says, "The designer is in effect a configurational thinker" [10].

Herbert [9] defined the architectural diagram as an analytic statement used to help the architect solve a problem. Design problems, in general, and architectural design problems specifically, are well-known examples of *wicked* or ill-formulated problems [18, 1]: problems that have no definitive formulation, no stopping rules, can always have more than one solution, and are unique in each case. This is aggravated by the constant need to negotiate between determinacy and indeterminacy [1] - a process that may be supported substantially by the use of diagrams. Somol [19] even suggested that, beyond a means of thinking, diagrams may actually be "the matter of architecture itself"; and furthermore that the architectural diagram has "seemingly emerged as the final tool... for architectural production and discourse".

This view of architectural diagrams acting as *more than* a mere representation aligns very well with Hillier's view in his book, Space is the Machine, where he suggests "the idea of architecture is at once a thing and an activity, certain attributes of buildings and a certain way of arriving at them. Product and process are not, it seems, independent. In judging architecture we note both the attributes of the thing and the intellectual process by which the thing is arrived at." [10] If, in this sense, architecture is both a thing and an activity, then surely, by extension, the architectural diagram can be both an activity (tellingly often

denoted by the verb 'diagramming' in architectural practice) and a thing, not only in of itself, but also as an interchangeable artifact standing for the, as yet, unrealised building. Even though some diagrams may never be realised as a building (which may make their significance debatable to some), they still represent their designer's intent.

3 From diagrams to language

If architectural diagrams are not merely a means for thinking about architectural design but have the potential to become the matter of architecture itself (c.f. Hillier's combining of product and process), the question arises whether there is a direct relationship between the qualities of an architectural diagram and the qualities of the resultant building. Does a 'clear' (however defined) diagram produce a more 'legible' building in Lynch's sense [15]? Does a diagram that is easy to understand result in a building that is also somehow clearer and hence more *usable* by the building's inhabitant? Could there be a translation from a building's diagram to its use that can be identified? To what extent would this depend on the observers' expertise? Do architects understand a building's diagram differently, or better, than non-trained observers? How does this relate to perceptions of the real building?

How could we begin to assess the comprehensibility or *clarity* of a diagram?[2] Hölscher and Dalton [11] asked architects and non-architects to gauge the complexity and perceived navigability of a set of buildings based on schematic floor plans. One interesting result was that building layouts that resembled commonly named-shapes (in this case a cross-shaped and a square-shaped layout) were judged very differently from the rest of the sample. These were prototypical examples of shapes with high "Prägnanz" (conciseness) as described in the literature on Gestalt psychology [13, 12]. Apart from representing highly familiar shapes for laypeople and architects alike, these layouts were also easily *describable*, since there existed common words to describe them. Thus, one measure of the *clarity* of a diagram might be how easily it could be described or 'put into words': how speakers *describe* diagrams may reflect what they *understand* about them. In this light, verbal descriptions of architectural diagrams might be key to the understanding of building complexity and, ultimately, usability.

So far, little is known about how diagrams are verbalised, and even less in the architectural domain. It is perhaps fair to say that the most relevant insights about the relation between diagrams and verbal description can be found in Barbara Tversky's work [22, 23, 24]. Tversky consistently takes verbal descriptions as a representation of thought, and finds that linguistic expression and other representation media, such as sketches and gestures, correspond to each other systematically in terms of structure and essential elements or features representing crucial aspects of conceptualisation. However, clearly there are also limits to the kinds of aspects that can or will be verbalised with respect to a diagram or any other pictorial representation. Linguistic representations generally focus on relevance [20] in a discourse context, rather than aiming to be fully exhaustive.

We will now present our study, which addresses the verbalisation of architectural diagrams directly, by investigating linguistic patterns in descriptions of diverse diagrams and building photographs, written by students with varying degrees of relevant subject knowledge.

[2] It is important not to confuse what we mean by clarity with Buchanan's assertion that (architectural) problem solving is about relationship between 'determinacy and indeterminacy' [1]. It could be argued that many 'clear' architectural diagrams can simultaneously exhibit both aspects of determinacy and indeterminacy but that this remains quite independent from the clarity of a diagram, since, in our view, clarity reflects the explicitness of the architectural intent.

3.1 Diagram selection and questionnaire design

In order to investigate the verbalisability of a diagram, we selected a consistent set of architectural diagrams, representative of a wide range of styles and from a diverse group of practicing architects, from a recent book on architectural sketches and diagrams[3] by Chris van Uffelen (2014) [25], as follows. We first identified a set of 37 diagrams that corresponded to our notions of an architectural diagram (namely exploratory, 'early-stage' diagrams that seemed to capture aspects of both determinacy and indeterminacy) but did not contain any words. We analysed this initial set in terms of their attributes, noting if they appeared to be drawn as a two-dimensional plan, section or elevation or as a three-dimensional view (or if the viewpoint was unclear). We then recorded the number of occurrences of current drawing elements, i.e. arrows, triangles, squares, rectangles, circles, ovals, spirals, curves/waves as well as 90° and non-90° angles. We considered whether the diagrams included graphic techniques such as hatching and shading and whether they included non-building symbols such as people/figures and foliage/trees. Finally we noted if and when the building corresponding to a diagram had been built in the real world.

From those buildings that had been constructed, we selected two that had a diagram drawn in plan view, two with a diagram representing a section (or elevation) view, and two with a diagram drawn in 3D. For each of these different iconic viewpoints we selected one relatively simple diagram (i.e., the frequency of graphical elements in the feature set was low, compared to the sample as a whole) and one more complex diagram (a relatively high number of graphical elements in the feature set). The final set therefore consisted of 1 x simple+plan; 1 x complex+plan; 1 x simple+section; 1 x complex+section; 1 x simple+3D and 1 x complex+3D yielding 6 diagrams in total (see Figure 3 for all diagrams used in this study[4], and Figure 2 for photographs of the actual buildings).

A questionnaire (approved, separately, by Northumbria University's Research Ethics Committee and by the College of Arts, Humanities, and Business Research Ethics Committee of Bangor University) was designed as follows. Prior to the main data collection, the questionnaire's purpose was explained and participants were asked to give their informed consent. Following the main data collection, anonymized demographic information was collected along with a set of questions designed to identify 'visual thinkers'.

Section 1 of the questionnaire presented participants with each of the six buildings' diagrams, in a sequential but randomized order, along with the instruction (repeated six times): "Please look at this image below. Describe the building as it is depicted in the image, in about three sentences." In Section 2, the same diagrams were shown again (re-randomized), along with the following instruction (again repeated for each diagram): "Please look at this image below. Identify and describe which 'elements' (i.e. lines, shapes, forms, patterns etc.) you can find in this image". In Section 3, a photograph, randomly ordered, of each of the real buildings for which the diagrams had originally been drawn was presented,[5] along with

[3] *Sketch* is a more general term; in architecture it typically means a freehand representation of what is seen, or what might be seen: i.e., a translation from vision to paper. The architectural *diagram* is more specific: this is about relations between building spaces, forms and functions, and about exploring these via the medium of the drawing.

[4] Copyrights for Figure 3: Top left: © Christian de Portzamparc Architect; Top middle: Fernando Romero, Mexico City, 2006; Top right: UNStudio Architects; Bottom left: copyright Daniel Libeskind; Bottom middle: Ana Rocha Architecture; Bottom right: Mr. Eduardo Souto Moura

[5] For copyright reasons, the pictures shown in Figure 2 differ slightly from the ones used in the study. Copyrights for Figure 2: Top left: Diego Baravelli; Top middle: Carlos Valenzuela; Top right: UNStudio Architects; Bottom left: Bernd Gross; Bottom middle: Ana Rocha Architecture; Bottom right: Chia Hsien Liao - LeonL. Top left and middle, bottom left and right are licensed under Creative Commons.

Figure 2 Building photographs. Top left: Cidade das Artes, Brasil: 2013 by architect Christian de Portzamparc; top middle: The Soumaya Museum, Mexico City: 2011 by Fernando Romero; top right: House Bierings, Utrecht: 2009 by Ana Rocha/Christian Richters; bottom left: Military History Museum, Dresden: 2011 by Studio Daniel Libeskind; bottom middle: Villa NM, New York: 2007 by Ben van Berkel; bottom right: Museu Paula Rego, Cascais: 2008 by Eduardo Souto Moura.

the following instruction (again repeated 6 times): "Here is one of the buildings that was shown as a drawing earlier. Please describe the real-world building in a few sentences." Thus, for each of the six buildings, three written descriptions were elicited: two for its diagram and one for its photograph.

3.2 Participant features

Two sets of students were invited to participate in the study: students of language-related subject areas (such as Linguistics or English Literature, henceforth "Language student" for short) at Bangor University in Wales, and students of Architecture at Northumbria University in England. These two subject areas were chosen because the study addresses the *language* used in the context of *architectural design*, produced by participants whose background is relevant in distinct ways. The questionnaire was available for two weeks. The only incentive was a prize draw for an Amazon voucher; no other payments were made.

Of the 37 respondents, 22 were female, 14 male and 1 preferred not to say. For consistency of analysis, we eliminated one age outlier (64 years) from the final data set, as well as 5 participants who were not native speakers of English, and 1 participant who failed to complete the questionnaire as asked. The final data set has 12 female, 5 male, and one gender-unidentified language students (mean age: 22.1; age range: 18-33), and 8 female and 4 male architecture students (mean age: 22.7; age range: 20-25).

6 female and 2 male architecture students and 7 female, 2 male, and 1 gender-unidentified language student self-identified as visual thinkers. 7 female and 1 gender-unidentified language students (but no male) considered themselves to be artistic, and 7 female and 3 male architecture students did so. Thus, while the data sets seemed fairly balanced in these respects, architecture students were (as might be expected) somewhat more likely to view themselves as visual thinkers and artistic. The same subject-related tendency was also reflected in the fact that all architecture students said they drew at least once a week or every day, whereas only four of the language students (3 female, 1 gender-unidentified) did so; 6 (3 males) said they could not remember when they last drew something, and 8 (2 males) drew once a month.

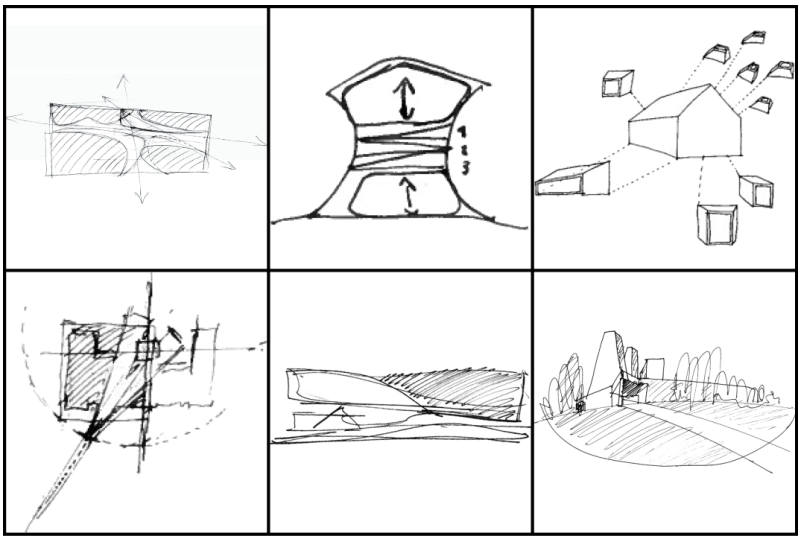

Figure 3 Architectural diagrams used in the study, shown in the same order and configuration as the photographs of the corresponding buildings in Figure 2. Top row: simple; bottom row: complex. Diagrams on the left: plan views; middle: section views; right: 3D views.

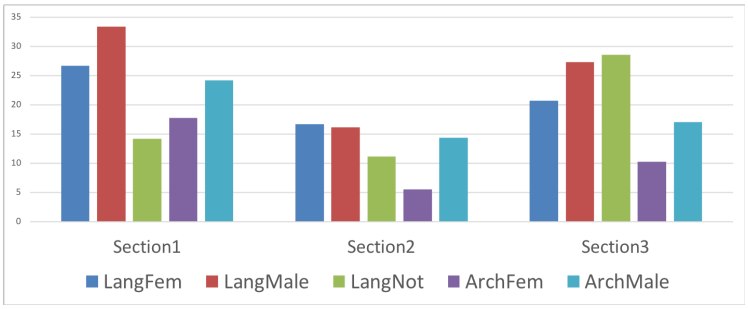

Figure 4 Mean word count in each questionnaire section. LangNot = gender-unidentified.

Subject-related and gender differences were also reflected in word count (see Figure 4).[6] Language students produced more words on average (female: 384.6; male: 460.4) than architecture students (female: 201.6; male: 322); variability of word count was reduced in female architecture students (range: 119-261) as compared to other groups (male architecture students: 151–748; female language students: 161-643; male language students: 137-805).

4 Cognitive Discourse Analysis

Our aim was to gain insights into the concepts represented in the language in an explorative way, in light of various aspects of the study design: the two groups of students with their different subject expertise, how students described diagrams as opposed to photographs, the different building views and varying diagram complexity, and possible differences according to gender. None of these factors can be ignored, but they are too diverse to aim for any

[6] Words were counted semi-automatically in Microsoft Excel. Likewise, further analyses were supported by Excel's features as far as feasible.

specific hypotheses based on inferential statistics, especially with unconstrained language production in an only loosely controlled data elicitation exercise, using a small sample size. Instead, we will present a qualitative analysis of linguistic patterns in our data following the methodology of Cognitive Discourse Analysis [21], which aims to identify conceptual aspects in discourse on the basis of systematic linguistic choices (beyond content).[7]

In the absence of specific hypotheses based on earlier literature we inspected the data to gain first insights about patterns in the responses that highlight the participants' underlying concepts systematically, in light of our motivating research question as to how architectural diagrams may be put into words and how verbalisability might relate to complexity and other features of the diagrams. To achieve systematic and objective annotation of our fairly large data set across various aspects, we then semi-automatically counted the occurrence of keywords in the following categories (emerging from the data, rather than predefined).

- **Peculiar**: Words indicating a sense of peculiarity (signalling challenges for legibility), namely *difficult, strange, unusual, unclear, peculiar, odd*
- **Possibility**: Indicators of tentative (i.e., possible rather than certain) interpretations: *seem, could, perhaps, appear, maybe, possible/possibility, ?*
- **Familiarity**: Words marking the respondent's familiarity with something (signalling legibility): *standard, traditional, exactly what, normal*
- **Structure**: Descriptions of structural elements (highlighting what kinds of structures were legible and verbalisable): *rectangle/rectangular, prism, triangle/triangular, square, boomerang, pyramid, box, hourglass, L-shaped, circle*
- **Function**: Mention of possible building functions (suggesting comprehension of the building in this respect): *public, school, theatre, museum, office*
- **Building/house**: Using the words *building* and *house* (reflecting conceptualisations of the building as a whole 3D entity)
- **Building parts**: Mention of any building parts in the house, such as *wall* or *window* (reflecting more fine-grained real-world concepts of the actual building functions)
- **Aesthetics**: Using terms that, in this context, indicate a sense of aesthetics (signalling usability and legibility in a different way): *organic, contrast, clean, feature*
- **Architectural**: Terms we identified in this context as architectural jargon, namely *circulation, intervention, extrude/extruding/intrude/intruding/extrusion/intrusion, orient/orientation, void, mass, material, symmetry*, plus Adrian Forty's "key words in architecture" [6]: *character, context, design, flexibility, form, formal, function, history, memory, nature, order, simple, space, structure, transparency, truth, type, user.*

Note that there is no intention for these different categories to be equal in size, nor comparable in any sense to each other. They are, however, mutually exclusive.

5 Results

To gain a first intuitive impression of the language data, consider some exemplary descriptions:

Female language student, Section 1, complex, plan view (bottom left in Figure 3): "This looks like a birds-eye plan of a building. It is comprised of different shapes and would appear to have a triangular shaped building (or something) at the very top."

[7] To clarify, this approach does not exclude inferential statistics but only advocates it where feasible, which it is not in this explorative study.

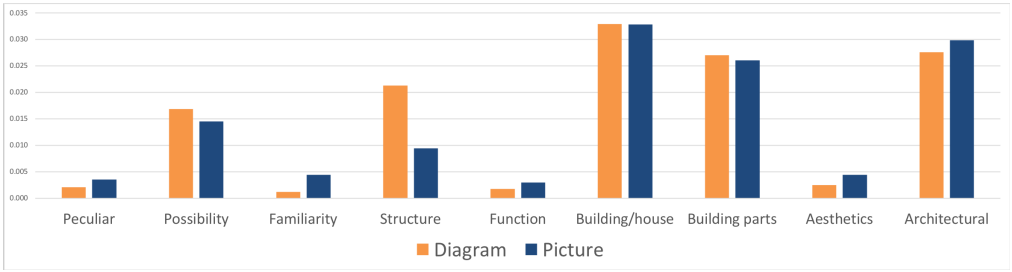

Figure 5 Comparing descriptions of architectural diagrams with pictures.

Male architecture student, Section 1, simple, section view (top middle in Figure 3): "Tall building, with dynamic shape. Two key large spaces with smaller intermediate floors. Long staircase covering entire width."

Male language student, Section 2, simple, 3D (top right in Figure 3): "The second drawing or outline in each dimension makes me think it has elevated surfaces."

Female architecture student, Section 3, complex, section (bottom middle in Figure 2): "Bold design which uses cladding which appears cold. The glazed aspect of the design allows views to a feature of the designs context."

All of these answers are relevant to the question asked; the students are evidently making an effort to describe the features they see and recognize. It is also remarkable that all descriptions, regardless of whether they pertain to a diagram (Section 1 and 2 of the questionnaire) or a photograph (Section 3) take the building seriously in its final design, although some uncertainty can be detected, particularly in the language students' examples. Indeed, intuitively the architecture students' descriptions seem different in some way; this is an effect of subject knowledge that we aimed to capture in more depth.

We found that female architecture students in Section 2, in particular, refrained from any kind of elaboration or speculation when describing the diagrams' elements, as reflected in a visible drop in the word count shown in Figure 4. Among those, a typical answer could be as short as "staircase" or "geometric cubes". Female language students' answers in Section 2 contrast sharply with this by being far more wordy and descriptive, and by frequently attributing function to form, as in "I see the circle which shows the area the building covers. Inside appears to be a shaded building, which could be the main focus, There appears to be a light sketch on the other side which could be the current building there." Again, the description seems tentative, trying to make sense of the diagram's features related to a *possible* building; in contrast, a female architecture student's crisp "Curved form floating above a void", like the other examples, seems to already describe *the building itself*.

Such observations motivated us to identify how linguistic indicators are spread throughout the data more systematically. We approached this by identifying patterns according to the various distinctions introduced by our design. Due to the high variability and diversity of patterns concerning word count reported above, our graphs show results in terms of percentages relative to total number of words in the relevant categories. Textual explanations provide raw numbers to demonstrate how often expressions actually occurred in the data. Patterns are described as they appear, with appropriate caution as to their significance; they may be suggestive but any stronger conclusions would require more controlled studies.

We start by noting that, in line with our initial intuition, descriptions of *diagrams* parallel those of building *photographs* concerning our chosen categories. As visualized in Figure 5, most categories are fairly equally represented in both types of representation. This is

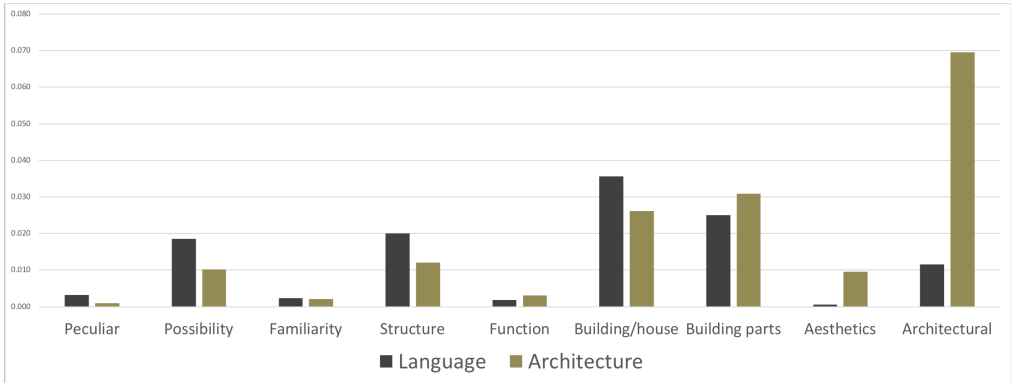

Figure 6 Results according to students' background.

remarkable in light of the fact that participants were not asked to make a direct comparison and never saw a building's photograph side by side with its diagram. The differences that we do find in the graph intuitively make sense. Expressions of familiarity appear to be more frequent with pictures (N=15 out of 3380 words) than with diagrams (N=8 out of 6806 words); most of these (N=14 in total) point to the fairly traditional or standard form of House Bierings, Utrecht. In contrast, descriptions of structure are more frequent with diagrams (N=145; buildings: N=32). Thus, it appears that diagrams represent structures more clearly than the actual buildings do. Functions and aesthetic aspects, in contrast, appear to be somewhat more prominent with photographs.

Concerning our two participant groups, subject knowledge is most clearly evident through the architecture students' enhanced use of architectural terms (*circulation, intervention, mass*, etc.; N=174; language students: N=82). Beyond this, the graph shown in Figure 6 suggests a range of further differences that together account, to some extent, for our previously observed impression that descriptions by architecture students seem different on the whole. In particular, language students tended to use more expressions of peculiarity (*difficult, strange, unusual* etc.; N=23) than architecture students (N=3), as well as expressions of possibility (*seem, perhaps* etc.; N=134; architects: N=30). Also, they referred to structures they recognised within the diagrams using non-architectural terms (*square, pyramid, hourglass* etc.; N=143) more than architecture students (N=34), and used the words *building* and *house* more frequently (N=258; architects: N=70). Relative to the overall number of words written, which was far lower in architecture students (2946 as opposed to 7240 written by language students), architecture students provided suggestions of possible functions (*public, school, museum*, etc.) more often (N=9) than language students (N=13), and they referred more often to aesthetic aspects (*organic, feature* etc.), (N=28; language students: N=4).

Next, we consider possible differences based on diagram complexity (see Figure 7). Against predictions, references to peculiarity seemed more frequent with simple diagrams (N=19) than with complex ones (N=7). However, expressions of possibility were somewhat more frequent in complex diagrams (N=90) than in simple ones (N=74), and expressions of familiarity (*standard, traditional*, etc.) appeared more often in simple diagrams (N=17) than in complex ones (N=6). Suggestions of structure were less frequent with simple diagrams (N=76) than with complex ones (N=101), but the use of architectural terms appeared to decline with complexity (N=141 simple; N=116 complex).

The type of building view in the diagram (see Figure 8) appeared to affect language use only with respect to a few of our categories. References to the words *building* and *house* seemed more frequent in the case of a 3D diagram (N=136 as opposed to N=110 with a plan

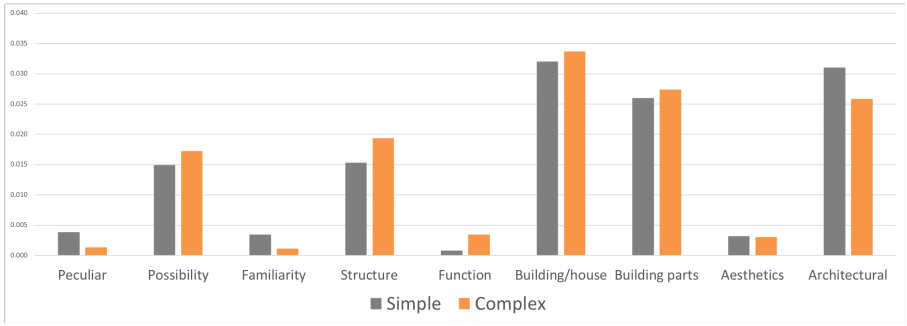

Figure 7 Results according to complexity of the diagram.

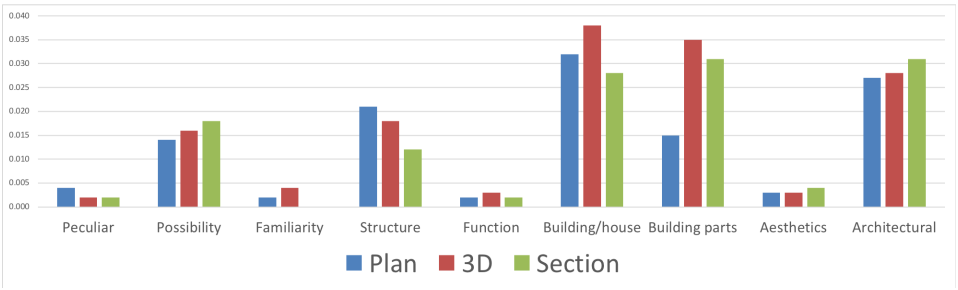

Figure 8 Results according to the type of diagram.

view and N=89 in the case of a section), suggesting that the idea of a building or house was more clearly visible. Structure seemed clearer with plan views (N=74) and 3D (N=66) than with section views (N=37). Plan views did not encourage recognition of specific building parts (N=51; 3D: N=125; section: N=96).

Finally, we can observe some tentative patterns concerning gender (Figure 9), beyond the word count differences noted in Section 3.2. Female participants tended to refer more to structures and used the words *building* and *house* more, and male participants used more expressions of possibility. (The gender-unidentified participant was excluded from this analysis.) We further noted that female architecture students were the only ones who used the words *North, East, South* or *West* in their responses (N=5, all in Section 1); the plan view diagrams may have invited this interpretation in the absence of actual compass information.

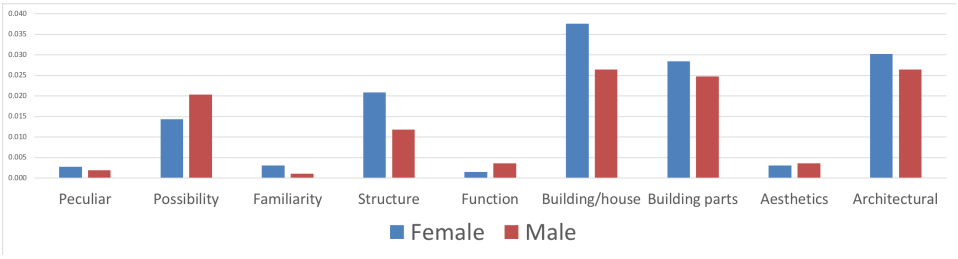

Figure 9 Results according to gender.

6 Discussion

We explored how architectural diagrams and their associated buildings are represented in language by people with different subject expertise, in light of various features of the diagrams. Results highlight a range of relevant observations that we hope will inspire future research. To start with, we note that this appeared a relatively easy task for both sets of students; in fact, the descriptions suggest that it may actually have been quite enjoyable[8] - even though it was an atypical and unusual task for all participants, for different reasons. It is not surprising that language students produced a far higher mean number of words, despite their lack of subject knowledge: architects generally prefer the media of drawing and talking more than the act of writing. The fact that it nevertheless proved quite easy to elicit text descriptions of the diagrams is encouraging, as it suggests that this might be a fruitful way to investigate the purpose, intent and range of possible interpretations of architectural diagrams.

The high degree of correspondence between descriptions of diagrams and building pictures, in terms of our linguistic categories, aligns with the idea that in architecture, diagrams have a particular significance in that they are as much the subject of architectural endeavour as the buildings themselves (see Section 2). Indeed, the designer does not actually 'make' the building – that is built by others – and so the only artifact that is touched by the hand of the 'creator' are the drawings (which includes diagrams). It is therefore reasonable that the drawings should *stand for* the creative intent of the architect and should have a status that is equivalent (in this respect) to the building. To what extent descriptions of photographs correspond to descriptions of actual building views and, ultimately, building experience and usage, is a matter of future investigation.

Our diverse analyses suggest various effects caused by the nature of the diagram (such as its level of complexity or whether it shows the building in plan or section view), as well as the observers' gender. There are, for instance, some indications that complexity matters for the degree of understanding of a building and its diagram, as shown by differences such as references to *possibility* or architectural terminology. These avenues could be pursued further in the future, to assess the relevance of any such systematic effects for building legibility.

Beyond these patterns, it is interesting to consider the ways in which subject knowledge affects diagram (and photograph) interpretation. Unsurprisingly, architecture students made heavier use of what we classed as technical terminology. Note however that only a few of the 'architectural' terms in our list (see Section 4 above) are exclusively used in the realm of architecture. Others, such as *structure*, are everyday words whose meanings may change with expertise [6]. Compare one language student's formulation *flat looking rectangular structure* with an architecture student's *simple pitched roof structure with extruded mirrored window boxes*. For language students, the term *structure* serves as a generic label used to describe whatever elements they can find; for architecture students, the term itself is meaningful, specifying, within their context, the nature of architectural design with respect to the elements described. Similar effects have been found in previous studies; for instance, professional background can affect how simple words such as *back* and *end* are used when describing pictures [3]. Ultimately, such differences in language use subtly convey diversity in how speakers *think* about what they perceive in a picture or in a diagram.

The idea that expertise affects how people conceive of diagrams and associated buildings is further corroborated by various other differences we found between our participant groups.

[8] To illustrate, here's a quote from the gender-unidentified language student, while describing the diagram of Villa NM in section 2: "An A-shape holding up a piece of pasta."

Altogether, the impression emerges that language students faithfully *describe what they see*, and use elaborate, cautious descriptions to speculate on possible meanings. For architects, in contrast, the simultaneous presence of both 'determinacy and indeterminacy' [1] is predominant; whilst the determinacy of the diagram shows the design-intent of the architect, it is the very indeterminent aspect of the drawing which permits diagrams to be 'read' on many different levels at the same time. Architecture students are being trained to produce such multi-level, multi-interpretable diagrams *for themselves*; this study indicates that this also contributes to the skill of interpreting the work *of others* in this way.

7 Conclusions and Outlook

This study brought together two hitherto fairly disconnected perspectives: the significance of the architectural diagram as a representation of design ideas [19], and the significance of linguistic choices in representing a speaker's perceptions [21]. The aim was to better understand how observers perceive architectural ideas as represented in diagrams.

Although explorative and qualitative in nature, a range of insights can be gained from this study. First, describing diagrams is feasible and yields meaningful linguistic data. Second, subject expertise (along with various further factors) affects descriptions in various ways; this highlights the different conceptualizations triggered by the visual information. It appears that the clarity of a diagram, or the ways in which it is understood, depends on who is interpreting it. It remains to be seen how these systematic differences in interpretation transfer to the real world building.

Supporting the idea of such a transfer, our third insight is that diagrams and photographs of buildings appear equally interpreted as representations of something real. The next step, accordingly, is to connect these representations to the actual buildings. Our ultimate aim (motivating this initial study) is to see whether a clear diagram (however defined) makes a more usable building (however defined), due to the legibility of its structures. This creates a clear need to take this work to the next stage: to relate diagram descriptions to navigation performance and further measures of the usability of the associated building.

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